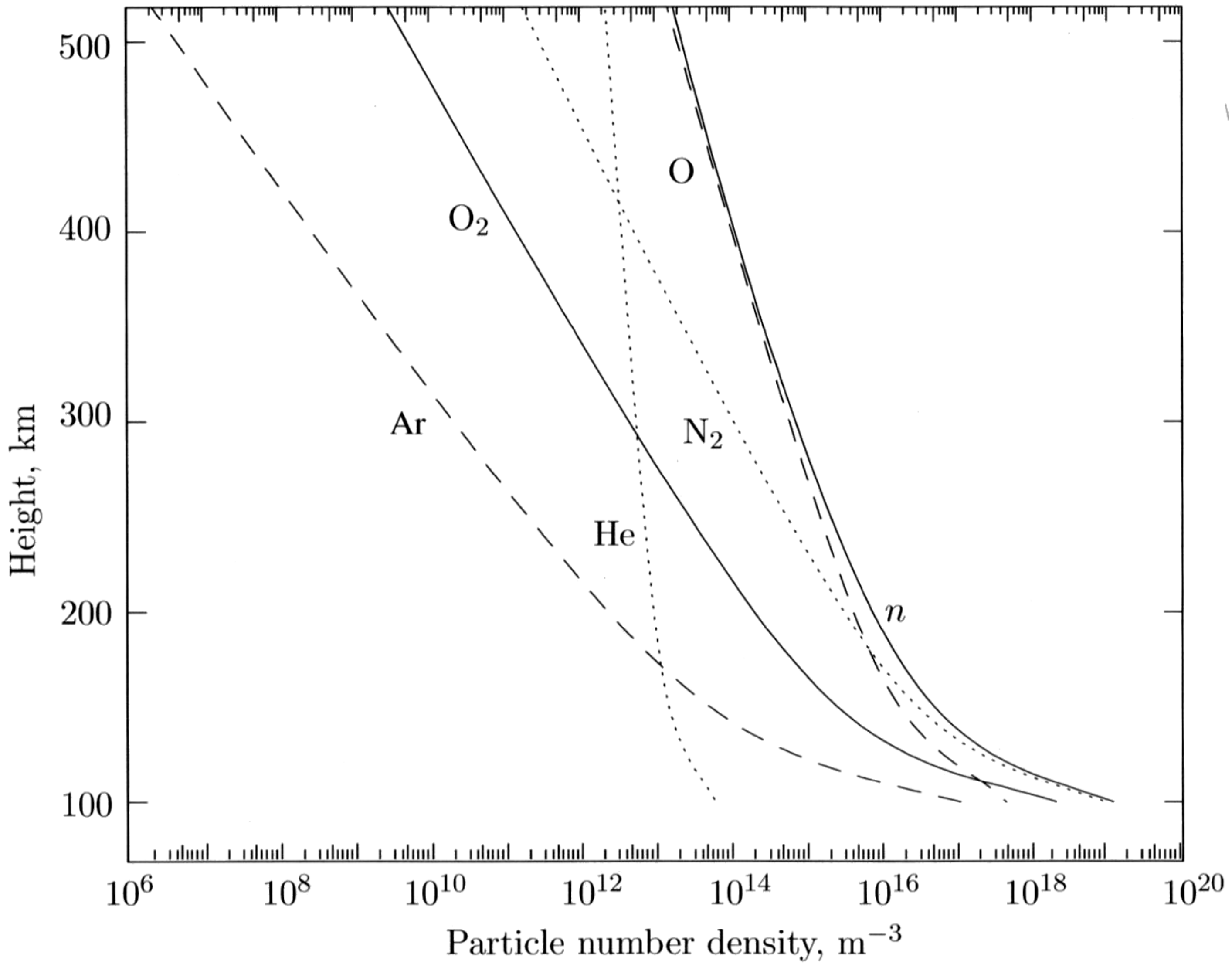
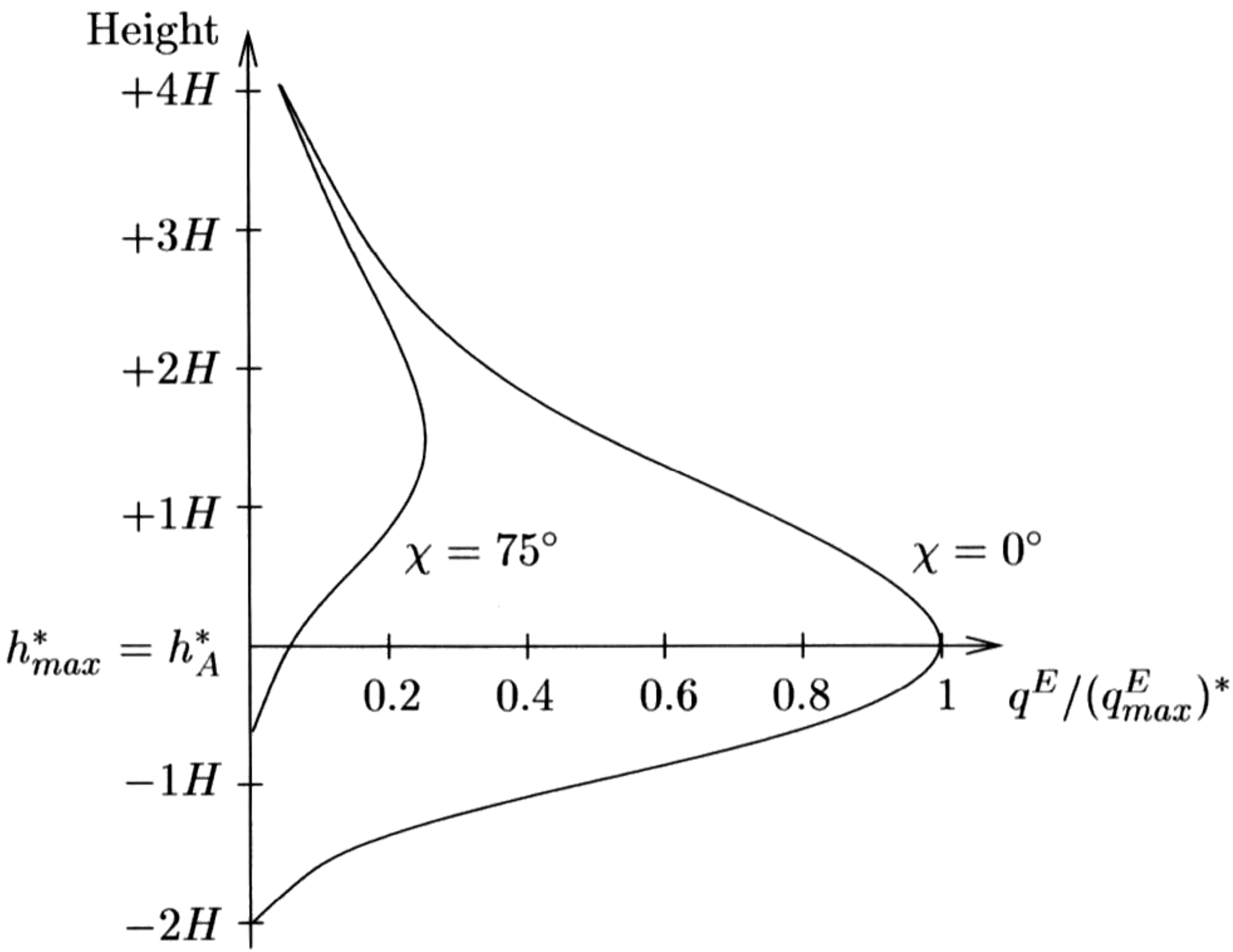
UiO : Department of Physics
University of Oslo

The ionosphere

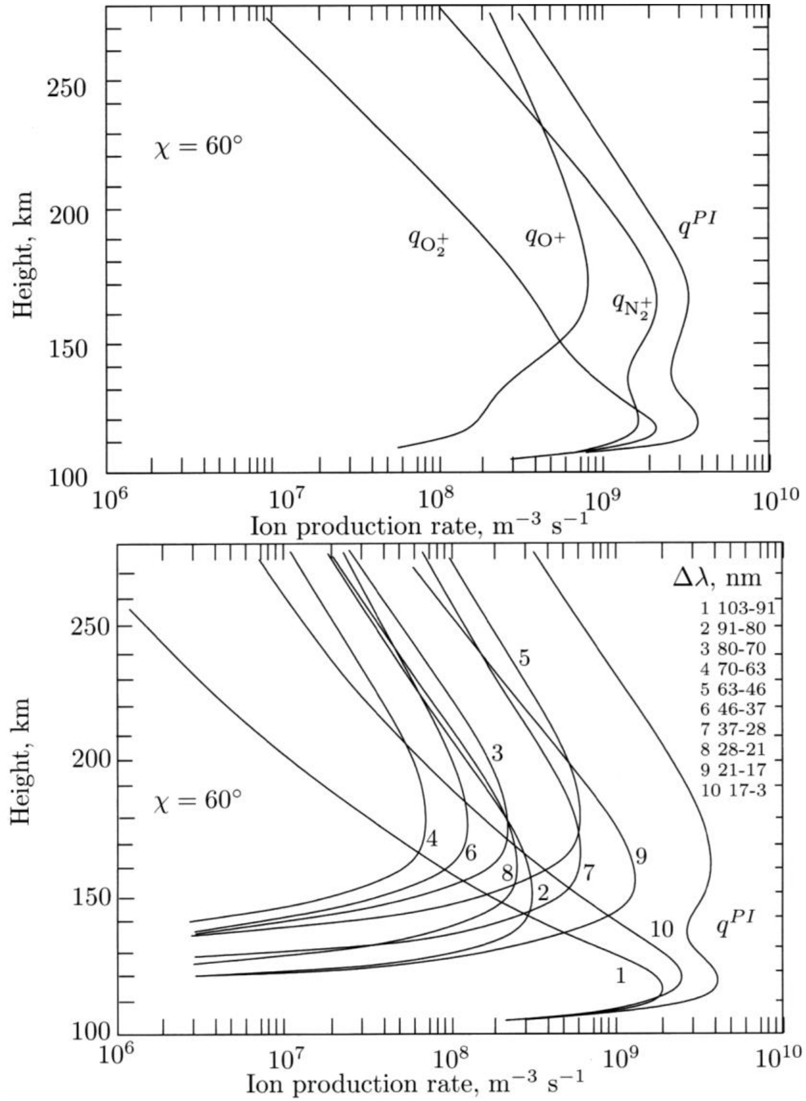
Neutral atmosphere



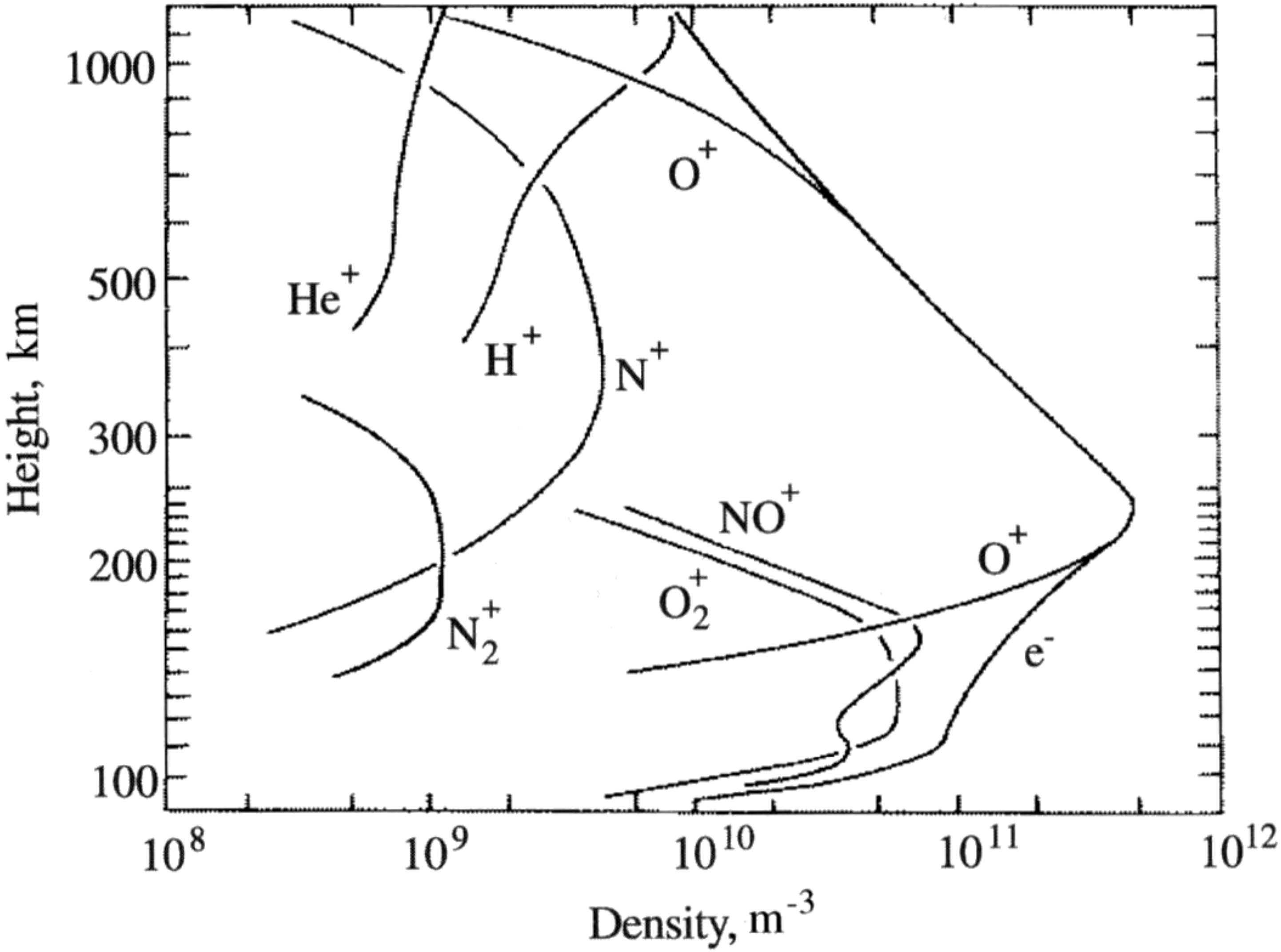
Chapman production function



Ion production rates



Ionospheric densities and composition



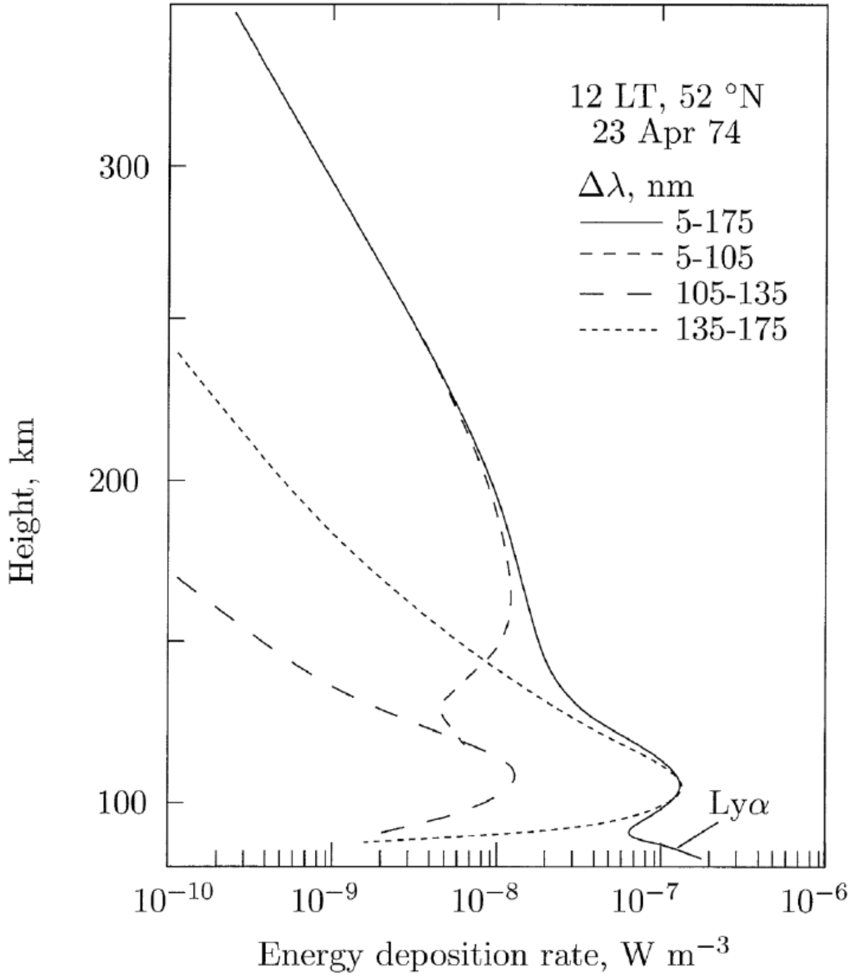
Reaction coefficients

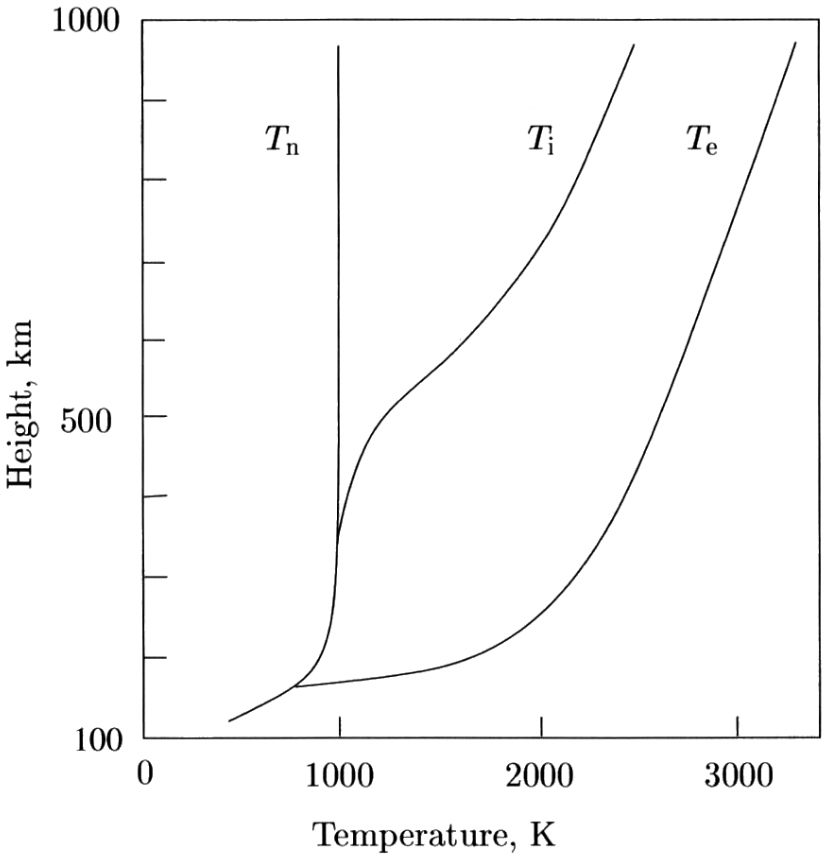
Table 4.3. Important chemical reactions in the ionosphere (adapted from Schunk, 1983)

(1)	$O^+ + N_2 \longrightarrow NO^+ + N,$	$k_1 = 1.533 \cdot 10^{-18} - 5.92 \cdot 10^{-19}\ (T/300) + 8.60 \cdot 10^{-20}\ (T/300)^2$; $300 \leq T \leq 1700$ K
		$k_1 = 2.73 \cdot 10^{-18} - 1.155 \cdot 10^{-18}\ (T/300) + 1.483 \cdot 10^{-19}\ (T/300)^2$; $1700 < T \leq 6000$ K
(2)	$O^+ + O_2 \longrightarrow O_2^+ + O,$	$k_2 = 2.82 \cdot 10^{-17} - 7.74 \cdot 10^{-18}\ (T/300) + 1.073 \cdot 10^{-18}\ (T/300)^2 - 5.17 \cdot 10^{-20}\ (T/300)^3 + 9.65 \cdot 10^{-22}\ (T/300)^4$; $300 \leq T \leq 6000$ K
(3)	$O^+ + H \rightleftharpoons H^+ + O,$	$\overrightarrow{k}_3 = 2.5 \cdot 10^{-17} \sqrt{T_n}$
		$\overleftarrow{k}_3 = 2.2 \cdot 10^{-17} \sqrt{T_i}$
(4)	$N_2^+ + O_2 \longrightarrow O_2^+ + N_2,$	$k_4 = 5 \cdot 10^{-17}\ (300/T)$
(5)	$N_2^+ + O \longrightarrow O^+ + N_2,$	$k_5 = 1 \cdot 10^{-17}\ (300/T)^{0.23}$; $T \leq 1500$ K
(6)	$N_2^+ + O \longrightarrow NO^+ + N,$	$k_6 = 1.4 \cdot 10^{-16}\ (300/T)^{0.44}$; $T \leq 1500$ K
(7)	$N^+ + O_2 \longrightarrow NO^+ + O,$	$k_7 = 2.6 \cdot 10^{-16}$
(8)	$N^+ + O_2 \longrightarrow O_2^+ + N,$	$k_8 = 3.1 \cdot 10^{-16}$
(9)	$He^+ + N_2 \longrightarrow N^+ + He + N,$	$k_9 = 9.6 \cdot 10^{-16}$
(10)	$He^+ + N_2 \longrightarrow N_2^+ + He,$	$k_{10} = 6.4 \cdot 10^{-16}$
(11)	$He^+ + O_2 \longrightarrow O^+ + He + O,$	$k_{11} = 1.1 \cdot 10^{-15}$
(12)	$N_2^+ + e \longrightarrow N + N,$	$k_{12} = 1.8 \cdot 10^{-13}\ (300/T_e)^{0.39}$
(13)	$O_2^+ + e \longrightarrow O + O,$	$k_{13} = 1.6 \cdot 10^{-13}\ (300/T_e)^{0.55}$
(14)	$NO^+ + e \longrightarrow N + O,$	$k_{14} = 4.2 \cdot 10^{-13}\ (300/T_e)^{0.85}$
(15)	$O^+ + e \longrightarrow O^{(*)} + h\nu,$	$k_{15} \simeq 1.4 \cdot 10^{-18}\ (1160/T_e)^{0.5}$

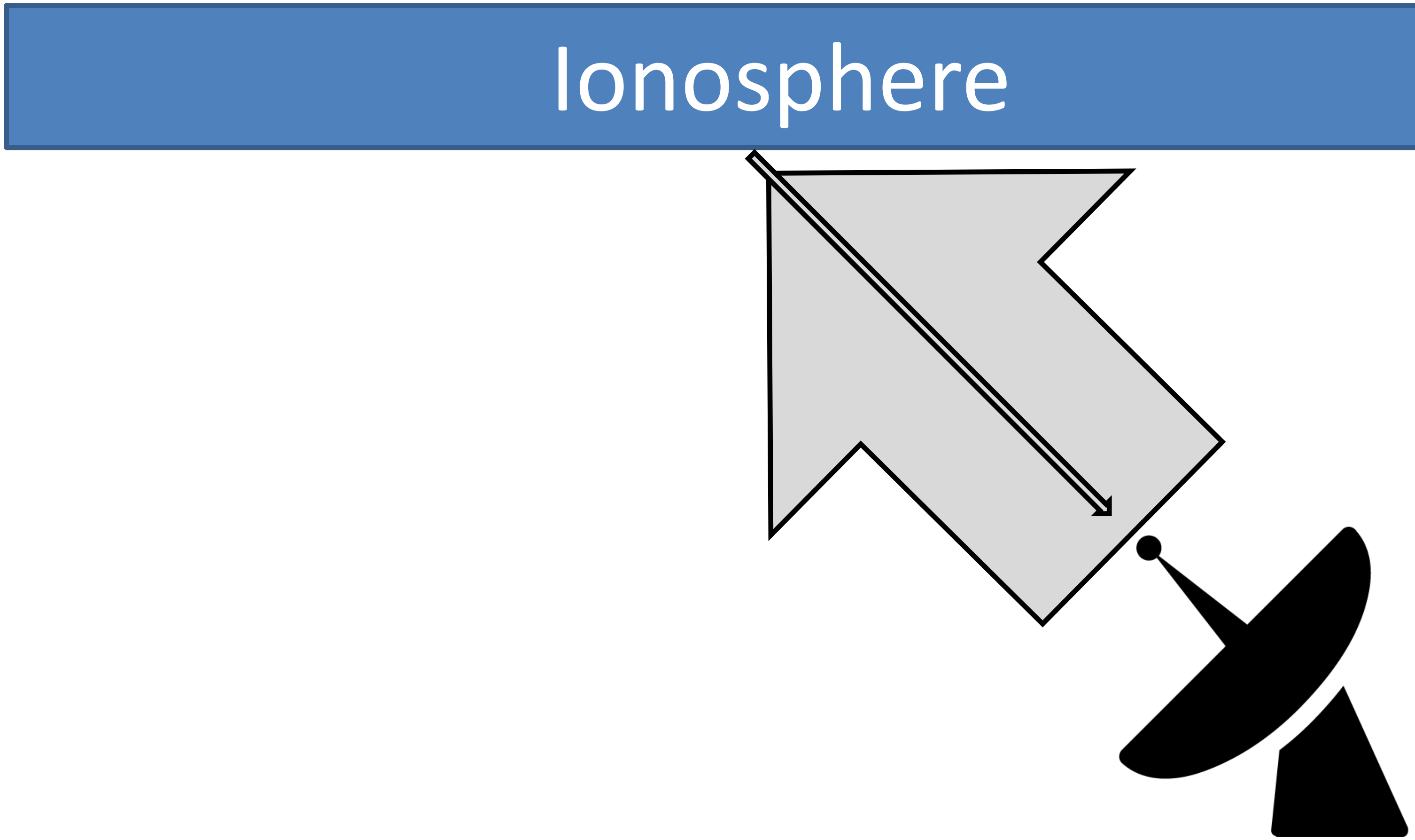
where the reaction constants k_i are in $[m^3 s^{-1}]$, $T \simeq T_n$ for small ion drift velocities and $T_i \simeq T_n$. In the presence of polar electric fields, the temperature in the F region increases as $T[K] \simeq T_n[K] + 0.33\,\mathcal{E}_{eff}^2[mV/m]$, where $\vec{\mathcal{E}}_{eff} = \vec{\mathcal{E}}_\perp + \vec{u}_n \times \vec{B}$ ($\vec{\mathcal{E}}_\perp$ = externally applied electric field component perpendicular to the magnetic field $\vec{B}$, $\vec{u}_n$ = neutral gas velocity and $\vec{B}$ = geomagnetic field vector; see also Section 7.5.2).

Energy input

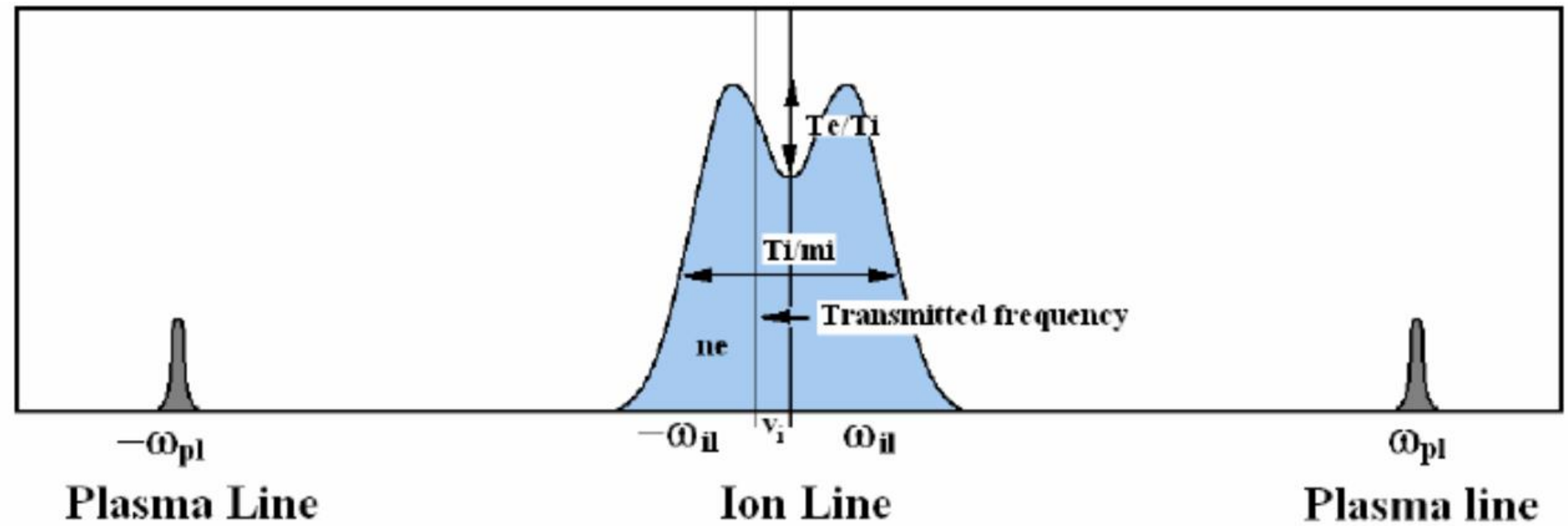




Incoherent Scatter Radar

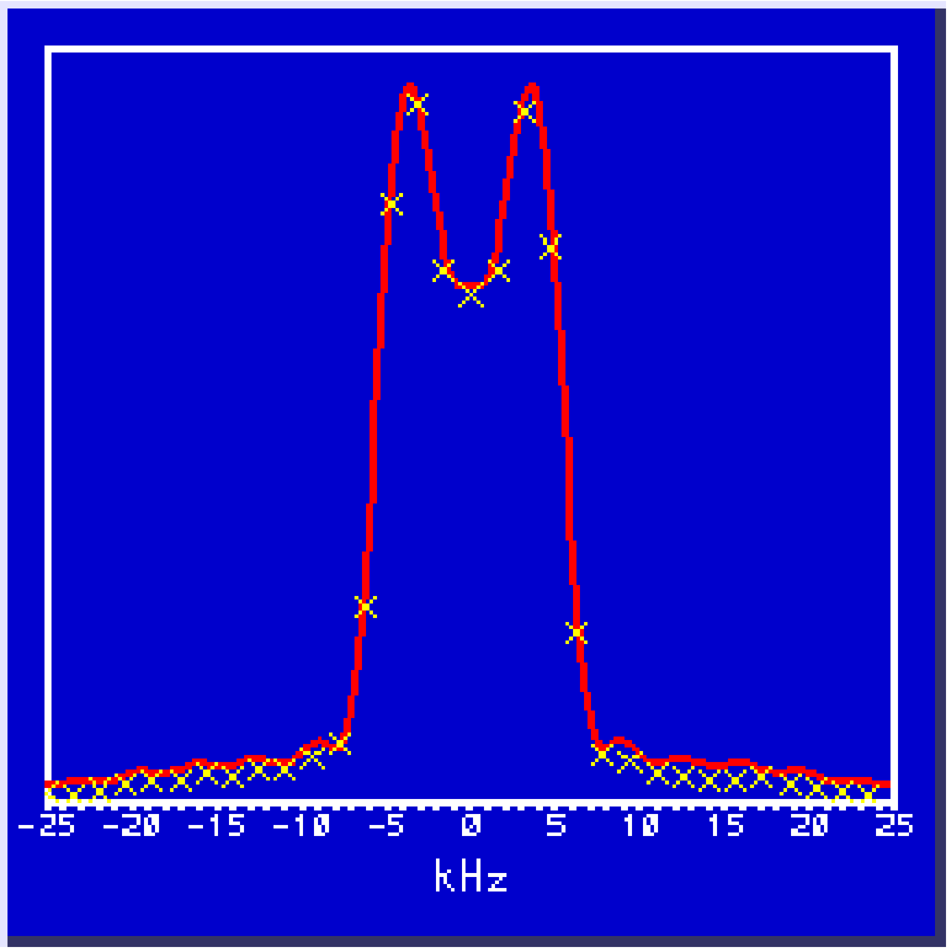


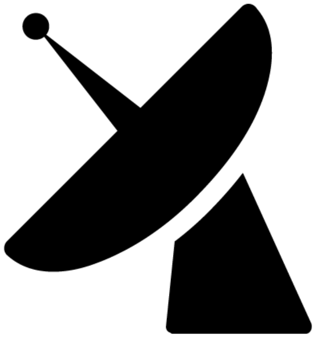
Incoherent Scatter Radar



Incoherent Scatter Radar

Incoherent Scatter Radar



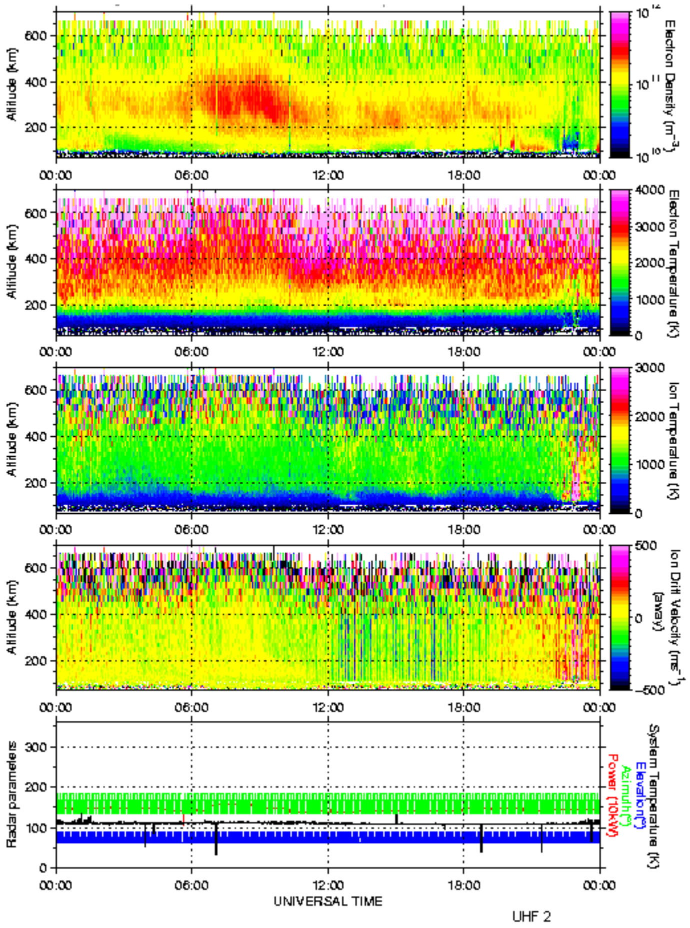


EISCAT

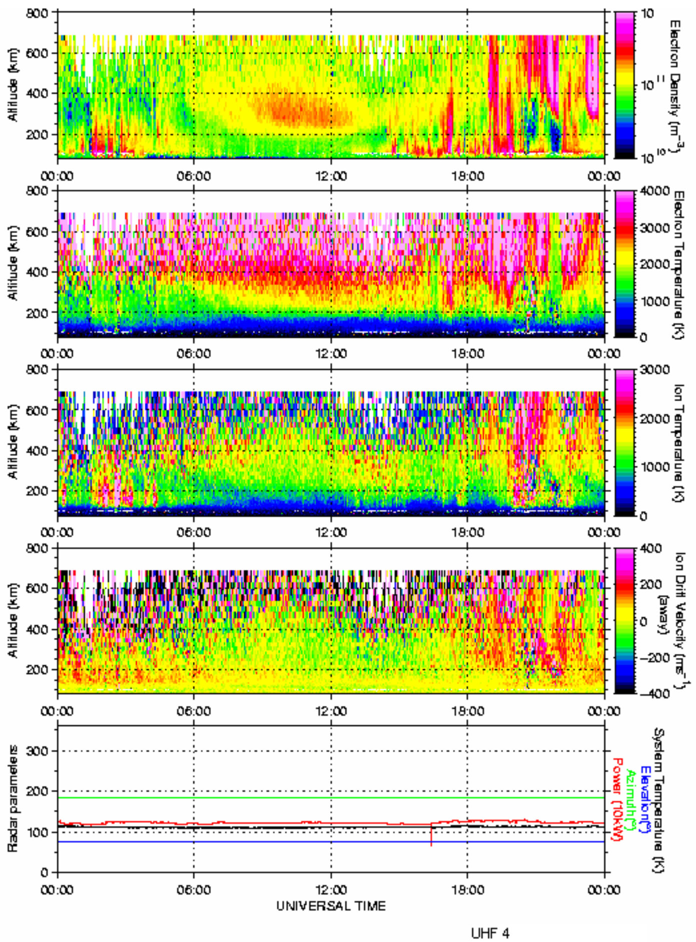
Dish

Dish

Example


Altitude (km)
Electron Density (m⁻³)
Electron Temperature (K)
Ion Temperature (K)
Ion Drift Velocity (ms⁻¹) (away)
Radar parameters
System Temperature (K)
Elevation(°)
Azimuth(°)
Power (10kW)
00:00
06:00
12:00
18:00
UNIVERSAL TIME
UHF 2

Example


Altitude (km)
Electron Density (m^-3)
Electron Temperature (K)
Ion Temperature (K)
Ion Drift Velocity (ms^-1) (away)
Radar parameters
System Temperature (K)
Elevation(°)
Azimuth(°)
Power (10kW)
UNIVERSAL TIME
UHF 4